Comprehensive Marine Particle Analysis System

Dr. Thomas Hopkins
Department of Marine Science
University of South Florida
St.Petersburg, FL 33701-5016
phone: (813) 553-1501 fax: (813) 553-3967 email: thopkins@marine.usf.edu
Award #: N00014-96-1-5020
Project Completion, 31 Dec. 98

LONG-TERM GOAL

The long term goal is development and utilization of a comprehensive (broadly capable) marine particle analysis system. The system is designed with wide dynamic range, thus, it will ultimately be used for high speed, high resolution characterization of water column particle fields in high, medium and low latitudes. As part of a broader goal this project continues advancement of the AOSN concept through joint use of both the towed platform and autonomous underwater vehicles.

OBJECTIVES

The project's objective is to develop a comprehensive marine particle analysis system which, along with other sensor systems, will enable us to address basic oceanographic, environmental and ultimately military issues. The objective includes adapting sensors to towed platforms and AUVs to characterize particle fields in a variety of oceanic environments.

APPROACH

The high resolution sampler (HRS) is designed to measure ocean properties that will provide insight into water column chemical, physical and biological processes. The platform has been used in Gulf of Mexico deployments to gather meaningful data and show efficacy. The approach for this project is to complete the sensor prototypes initiated in the period 1994 to early 1997; test them at the USF Center for Ocean Technology (COT); sea-test them on the HRS towed platform; and then adapt sensors, as available, to Florida Atlantic University AUVs. Deployments of the HRS in the Gulf of Mexico are part of this project. Acquired data will allow researchers access to an enhanced data set for improvement and advancement of their models.

WORK COMPLETED

A. Sensor Development

i. Shadowed Image Particle Profiling and Evaluation Recorder (SIPPER)

This instrument counts and sizes particles by analyzing particle silhouette images cast on a linear array camera (Figure 1). Specifically completed work includes: 1) design and construction of an 80MB per second data storage system; 2) pressure vessel design (complete), construction in progress at this writing; 3) integration of Echelon LONWorks control; 4) real time data subsampling system for user on-the-fly control; 5) Win95 control software; 6) elementary image analysis using commercial software; 7) data display software.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
1998		**00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Comprehensive Marine Particle Analysis System	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of South Florida,Department of Marine Science,St. Petersburg,FL,33701-5016**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

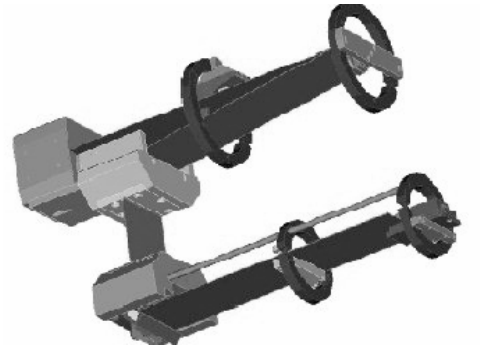
12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

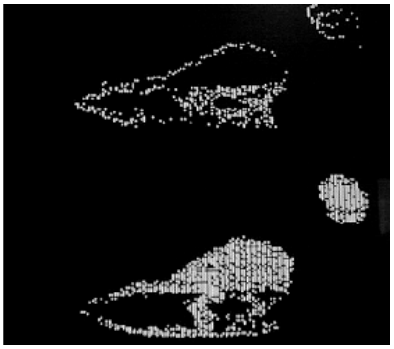
13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**6**	





a) ***b)***

Figure 1

a) Exploded view of SIPPER optical system. b) Copepod image captured in 2 modes ("edge detect" and "solid body") for 2 mm critter. Images shown are for 1 dimension only and are ½ resolution.

ii. Particle Image Recorder (PIR)

This instrument is designed to video record marine particles as they are entering the towed platform main sample port. Two modes of operation have been designed into this system: 1) strobe "still frame" mode and; 2) CW mode where a tungsten lamp illuminates the sample volume continuously. Mode 2 allows determination of particle movement with respect to the towed platform by streak pattern analysis. This system is under construction and is expected complete in the near future.

iii. Chirp Bio-scatter Sonar

Work is continuing on packaging the unit for deployment on the HRS and OEX platforms.

iv. Microparticle Analysis

A complete fractionation and detection system has been developed to determine the joint particle property distribution (size-composition-concentration) using a flow field flow fractionation system and a UV-VIS fiber optic based waveguide. The flow field flow fractionation system has been demonstrated to separate particles based on their diameter at very high resolutions (~2 nm). A waveguide was developed with the intention of using current expertise in obtaining the joint particle property distribution, from standard UV-VIS transmission measurements. The waveguide/fractionation system has been validated using submicron polystyrene standards. Currently, the research is focused on separating and classifying particles and cells above one micron with the detection system.

Two prototypes for the multiangle-multiwavelength (MAMW) detection system have been developed. The first prototype is a versatile system, designed for on-line characterization of the joint particle property distribution (size-shape-concentration-composition). The second prototype provides sensitive and high precision angular measurements for bench top analysis. During the past year, the MAMW has demonstrated five orders of magnitude of scattering measurement sensitivity. Various particles have also been tested including polymers, blood, and silver halides. It was apparent from these measurements that the composition and, thus, the identification of particles will be possible. In terms of the hardware development, the MAMW detection system was calibrated against standard scattering theory. The shape analysis of particles, including biological particles, inorganic particles and polymers, will occur during the next six months. The transmission mode of detection has been completed and interpretation of particle size distributions fully tested with a large variety of standards.

v. Dual Light Sheet (DLS)

This sensor was completed in late 1997 with AUV testing in June 1998 and HRS testing in July and September 1998. A velocity measurement system was integrated into the DLS along with a logging microcontroller. AUV testing showed excellent results, however, apparent electrical problems hampered thorough testing on the HRS. The instrument has shown capability to measure and count particles in the size range of 500 micron to 6 millimeters ESD. As part of the particle velocity measuring system, software was developed to analyze generated data. The software uses an autocorrelation algorithm to calculate particle velocity to approximately 2% accuracy. Data from the June 1998 AUV test deployment showed very close match to AUV speed information.

B. Platform Development

i. Development and testing of an HRS small particle verification rosette water bottle system.

The need to gather water samples to analyze small particles is part of the HRS development project. A system by which (10) 1.2 liter Nisken bottles can be triggered using the HRS net sample wheel has been designed. Integration of this system into the HRS design was completed and tested in the Gulf of Mexico. The system as designed worked well and provided water samples for nutrient and particle analysis.

ii. HRS System Improvements

The HRS software and hardware were upgraded with minor improvements over the past year. Included were: 1) Real time GPS data recording; 2) automated file storage system on sample net increment; 3) optical fiber ethernet capability through the tow cable; 4) improved electrical isolation and connection means.

iii. Dual Light Sheet AUV integration

The Dual Light Sheet AUV integration was improved with integration of a logging, LONWorks interfaced, microcontroller. This upgrade allowed simplified integration with the Ocean Explorer AUV as LON modifications were not necessary in the vehicle.

C. HRS and AUV Deployments

i. AUV Deployment of Dual Light Sheet (DLS) instrument

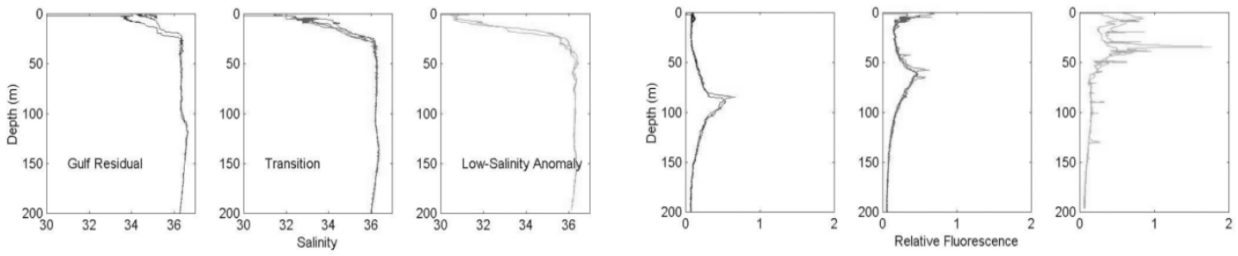
The DLS was deployed at Lee Stocking Island in a test configuration during CoBOP operations. The sensor recorded data internally and was operated in a lawnmower pattern for 1.5 hours at a 2 meter depth. Post processing of data showed results as expected for the low particle density water sampled. Ship gathered bottle samples showed *Trichodesmium* colonies in concentration and size in line with gathered particle data. Post processed particle (water) velocity measurements using the Dual Light Sheet showed close correlation with AUV speed data.

Additional AUV deployments are planned for the DLS instrument including at the FAU South Florida Test Facility and in near shore Florida west coast waters in conjunction with a multi-vehicle operation.

ii. HRS Deployments

HRS testing and sampling was conducted in two marine environments in 1998: 1) the oceanic eastern Gulf of Mexico (eGoM), where a low salinity anomaly was detected; and 2) the coastal West Florida Shelf (WFS), in support of the ONR HyCODE and NOAA/EPA ECOHAB:Florida studies. In the eGoM study (20 Jul-2 Aug), an unusual frontal region was detected in a normally horizontally-homogeneous water mass. This frontal region separated two distinct water masses: low salinity water,

presumably of riverine origin and eastern Gulf residual water, with transition water occupying the front itself (Figure 2a). In addition to physical data, the HRS revealed biological differences between the water masses, with distinct chlorophyll biomass (Figure 2b) and zooplankton-sized particle characteristics (Figure 3) associated with each. These data are being made available, on request, for the Minerals Management Service study "Analysis of Anomalous Oceanographic Conditions on the Northeast Gulf of Mexico Shelf".



a) ***b)***

Figure 2
a) Salinity profiles for three water masses in the oceanic eGoM b) Relative fluorescence profiles for three water masses in the oceanic eGoM.

In the WFS study (22-24 Sep), the HRS was employed to map the fine-scale distribution of hydrography, nutrients, chlorophyll, zooplankton, and suspended particulates across the ECOHAB:Florida control volume. The data generated with the HRS, equipped with a rosette water bottle system, have revealed several previously unknown features of the WFS, including fine-scale zooplankton-sized particle patchiness (Figure 4) as well as nutrient and chlorophyll patchiness. In particular, we found that relative nutrient spatial gradients were ten-fold those of temperature and salinity. Net samples, integrated with optical particle data, will provide the key grazer component of modeling efforts directed at understanding the ecology of harmful algal blooms.

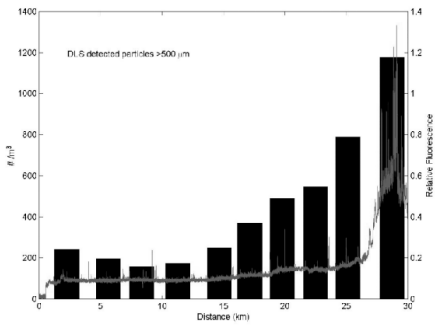


Figure 3
Zooplankton-sized particle distributions and relative fluorescence associated with and oceanic low salinity anomaly front (20-30 km from origin of transect).

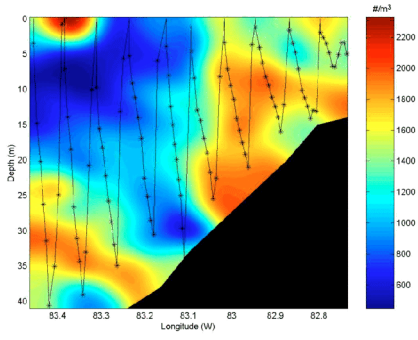


Figure 4
Fine-scale patchiness of zooplankton-sized particles across the ECOHAB: Florida control volume (West Florida Shelf).

i. Establishment of a laboratory photography/image analysis system to process samples collected with the HRS carousel plankton codends.

The current system, constructed by Tracey Sutton, consists of three components: 1) microscope with video camera adapter; 2) camera/monitor system; and 3) computer/software system. Video images of HRS samples are obtained via a Sony DXC-970MD 3CCD color video camera mounted on an Olympus SZH10 stereoscope. These video images are routed to a Sony Trinitron color monitor through a Sony Color Video Printer. The monitor outputs to an Integral Technologies FlashPoint PCI frame grabber board installed in a Compaq Deskpro 6000 (Pentium 200 MHz) computer. The images are then processed real-time via Optimas 6.1 image analysis software. The advantages of this system are: 1) particle measurement rate and accuracy are increased via mouse-driven cursor controls (vs. ocular micrometer methodology); 2) sample images can be archived on optical disk for further analysis; and, 3) data are downloaded real-time to Windows-based spreadsheet programs, thus reducing the time and human error of manual data entry.

RESULTS

•Data gathered from HRS II deployments provided information for ECOHAB model. •AUV mounted particle sensor was tested. Data was retrieved showing excellent results including prove-out of particle velocity measurement system. •New optical technique for recording suspended particles was tested opening the door to automated rapid assessment of particle distributions and classification. •New optical technique for the analysis of submicron particles was developed and tested. The method is inexpensive and compact, opening opportunity to use instruments based on the technique on AUVs or buoys. •A lab-based plankton analysis facility was created for truthing of electronically acquired data. This will allow for identification of problems with developed instruments and ultimately improve electronically acquired data sets.

IMPACT/APPLICATIONS

This project represents a directed effort to build and test systems for characterization of a wide variety of marine environments. Data gathered has direct application to predictive biological process models. The sensors being developed and tested are targeted for deployment on modern AUV's. Experience gained in deploying and developing sensors for AUV's will have significant impact on defining the appropriate tools for future automated monitoring of the ocean.

TRANSITIONS

The data output of this project will be of interest to programs such as ECOHAB. Others involved in the optical properties of water, and those creating biological - chemical - physical process linked models will use the data. Data gathered will also be used in optimization of AUV sensor deployments.

RELATED PROJECTS

1) Enhanced In-Situ Spectroscopic Analyses of Trace Seawater Solutes; 2) Construction of In-Situ Underwater Mass Spectrometer

REFERENCES

1) Davis, C.S., S.M. Gallager, M.S. Berman, L.R. Haury and J.R. Strickler. 1992. The video plankton recorder (VPR): Design and initials results. Arch. Hydrobiol./Beih. Ergebn. Limnol. 36: 67-81.

2) Herman, A.W. 1992. Design and calibration of a new optical plankton counter capable of sizing small zooplankton. Deep-Sea Res. 39: 395-415.